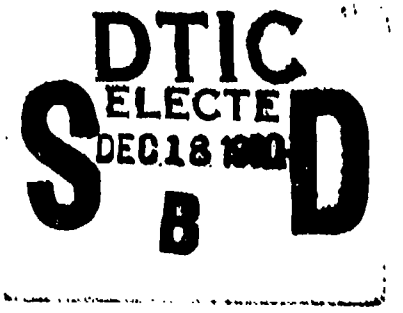
Research Product 91-02

Range Target System (RTS) Operations Manual: Annex 1: Pop-Up Target System (PTS) Operations and Maintenance Reference Manual



October 1990

Fort Bliss Field Unit
Systems Research Laboratory

U.S. Army Research Institute for the Behavioral and Social Sciences

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

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Research accomplished under contract for
the Department of the Army

Science Applications International Corporation

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NOTICES

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS --
2a. SECURITY CLASSIFICATION AUTHORITY --	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE --	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) --	5. MONITORING ORGANIZATION REPORT NUMBER(S) ARI Research Product 91-02
6a. NAME OF PERFORMING ORGANIZATION Science Applications International Corporation 6b. OFFICE SYMBOL (If applicable) --	7a. NAME OF MONITORING ORGANIZATION U.S. Army Research Institute Fort Bliss Field Unit
6c. ADDRESS (City, State, and ZIP Code) 5959 Gateway West, Suite 542 El Paso, TX 79925	7b. ADDRESS (City, State, and ZIP Code) P.O. Box 6057 Fort Bliss, TX 79906-0057
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U.S. Army Research Institute for the Behavioral and Social Sciences 8b. OFFICE SYMBOL (If applicable) PERI-S	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MDA903-85-C-0460
8c. ADDRESS (City, State, and ZIP Code) 5001 Eisenhower Avenue Alexandria, VA 22333-5600	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 63007A; PROJECT NO. 793; TASK NO. 1201; WORK UNIT ACCESSION NO. C01

11. TITLE (Include Security Classification)
Range Target System (RTS) Operations Manual: Annex 1: Pop-Up Target System (PTS) Operations and Maintenance Reference Manual

12. PERSONAL AUTHOR(S)
Berry, M. Gene; and Barber, Andrew V. (SAIC)

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 88/10 TO 90/09	1990, October	

16. SUPPLEMENTARY NOTATION
Contracting Officer's Representative, John M. Lockhart

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP
05	08	
23	02	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Short Range Air Defense (SHORAD) FAAD
Forward Area Air Defense Helicopters
Engagement simulation

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Range Target System (RTS) is a high-fidelity engagement simulator. Short Range Air Defense (SHORAD) and Forward-Area Air Defense System (FAADS) crews employ their actual weapons in simulated or live fire engagement of sub-scale, fixed-wing and rotary-wing aircraft. RTS permits training and evaluation of individuals, crews, and platoons, provides detailed crew performance scoring and feedback, and can be moved from one location to another and rapidly put in place for a new training exercise or test application.

This reference manual describes the Pop-Up Target System (PTS) component of RTS. All relevant operations and maintenance procedures are discussed, along with a detailed description of the Pop-Up Target System, PTS power and environmental requirements, necessary test equipment, and important safety considerations. This PTS reference manual is Annex 1 to the separately published RTS Operations Manual, ADA230 095. Keywords: Antiaircraft defense systems; Army training devices; Guided missile personnel; Gun crews; Antiaircraft gunnery trainers; Aptitude; Aft missiles; Helicopters; Instructional manuals; Aerial targets; Military exercises. (EDC) AF

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
John M. Lockhart	(915) 568-4491	PERI-SB

DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

Research Product 91-02

Range Target System (RTS) Operations Manual: Annex 1: Pop-Up Target System (PTS) Operations and Maintenance Reference Manual

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October 1990

Army Project Number
2Q263007A793

Human Factors in Training
Operational Effectiveness

FOREWORD

The Crew Weapons Performance Team of the Fort Bliss Field Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) performs research and development to improve soldier-system effectiveness in air defense. This research effort is supported by the Realistic Air Defense Engagement System (RADES), a sub-scale facility that realistically simulates critical aspects of the forward area engagement environment. To address air defense training and evaluation deficiencies, U.S. Army Air Defense Artillery School (USAADASCH), U.S. Army Missile Command Target Management Office (MICOM-TMO), and ARI combined to integrate RADES target presentation, performance measurement, and engagement simulation capabilities into the Range Target System (RTS) and to validate crew engagement standards in the RTS. The RTS is a high-fidelity engagement simulator. Short Range Air Defense (SHORAD) and Forward Area Air Defense System (FAADS) crews employ their actual weapons in simulated or live fire engagement of sub-scale, fixed-wing and rotary-wing aircraft.

This ARI Research Product is an operations and maintenance reference manual for the Pop-Up Target System (PTS) component of RTS.

Development and validation of the RTS was authorized by a Memorandum of Agreement between USAADASCH and ARI, subject "Realistic Air Defense Engagement System Applications," dated 14 February 1986.

RTS was demonstrated to the proponent, COL Whitley, Director of Training Development, USAADASCH, on 25 September 1989. RTS was also demonstrated for COL Bridgewater, OSD ADA T&E, 27 September 1989; Mr. Estorga, Technical Advisor, TEXCOM-ADAB, 8 November 1989; and COL(P) Hardy, 7th ATC, FRG, 4 December 1989.

LTG Crosby, DOG-T, TRADOC, approved the development and validation of SHORAD engagement standards by ARI in the RTS (SHORAD Weapon Systems Program Review, 26 October 1988). BG Custer, Assistant Adjutant General, NM ARNG, approved the use of RTS to provide individual and collective training for New Mexico National Guard SHORAD battalions (letter dated 25 May 1990).

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Technical Director

RANGE TARGET SYSTEM (RTS) OPERATIONS MANUAL: ANNEX 1: POP-UP TARGET SYSTEM (PTS) OPERATIONS AND MAINTENANCE REFERENCE MANUAL

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RANGE TARGET SYSTEM (RTS) OPERATIONS MANUAL: ANNEX 1: POP-UP TARGET SYSTEM (PTS) OPERATIONS AND MAINTENANCE REFERENCE MANUAL

1.0 INTRODUCTION

This manual provides instructions for operating the Pop-up Target System (PTS), developed by Science Applications International Corporation (SAIC), in conjunction with the Range Target System (RTS), also developed by SAIC under Contract No. MDA903-85-C-0460 with the U.S. Army Research Institute for the Behavioral and Social Sciences. Refer to the RTS Operations Manual for more details.

1.1 Purpose and Function

The purpose of the Pop-up Target System (PTS) is to present realistic friendly and threat helicopter targets for live fire and engagement simulation training and testing. The PTS provides a cost-effective means for developing those skills necessary to acquire, identify, and engage helicopter targets.

To accomplish this purpose, SAIC utilizes 1/5 scale helicopter models, mounted on the stand-lift device, which can be remotely controlled to present (raise) the target from a defilade (hidden) position, simulate hover (stationary with main rotor rotating), and disappear (lower) on command.

WARNING: Do not attempt to perform any of the functions contained in this manual without sufficient training and practice, at risk of injury or death.

1.2 Capabilities

The system is operated remotely from the RTS Range Control Station (RCS) that controls all portable PTS mechanisms (usually 6). This control is accomplished through a radio frequency (RF) datalink or via cable. Each PTS is capable of having any one of nine helicopter models (5 US, 4 Soviet) mounted on it.

1.3 Performance Characteristics

The PTS allows an operator at the RCS to perform the following: rotate each target left or right to present any desired target orientation, raise and lower any single target or all targets, and generate and store a recoverable scenario script for later automated target presentation.

1.4 Safety

Care must be exercised when working around the PTS and when operating the system from the RCS. Warnings are used throughout this manual to make the user aware of conditions which could cause serious injury to personnel. Cautions are also used in this manual which indicate conditions which could cause damage to equipment. All warnings have been compiled and are listed below:

WARNING: Do not attempt to perform any of the functions contained in this manual without sufficient training and practice, at risk of injury or death.

WARNING: The stand-lift mechanism must operate in an area free from all obstructions for a height of 12 meters (39 ft) and within a radius of 4 meters (13 ft) of the telescopic mast.

WARNING: Drain all air from the air tank to prevent accidental raising of the telescopic mast assembly during the following procedures and disconnect J4, AC power to the drive motor.

WARNING: Lift the helicopter body with a minimum of two persons (one front, one rear).

WARNING: Securely tighten the mounting chuck with the key wrench to prevent the rotor blades from coming off during rotation.

WARNING: Rotor blades will begin to rotate upon receipt of an UP command and will continue to rotate for awhile after the target has been lowered. Maintain an area free of additional personnel and any obstructions for a radius of 4 meters (13 ft) from the telescopic mast assembly, and for a height of 12 meters (39 ft).

WARNING: Prior to turning on the main circuit breaker, verify all switches on the local control panel are in the OFF position.

WARNING: The stand-lift mechanism must be dismounted from the 1/4 ton trailer and placed on a flat surface to prevent movement during the following procedure.

WARNING: The generator weighs 109 kg (240 lbs). After the mounting bolts are removed, care must be exercised to prevent injury to personnel when removing or replacing the generator.

WARNING: Air pressure in excess of 100 psi can be encountered. Drain the air tank before proceeding.

WARNING: The air compressor weighs 27 kg (59 lbs). After the mounting bolts are removed, care must be exercised to prevent injury to personnel when removing or replacing the air compressor.

1.5 Dimensions and Weight

1.5.1 RCS

The primary equipment comprising the RCS is stored and transported in its own container. This container is 56 x 81 x 107 cm (22 x 32 x 42 in), and weighs 41 kg (90 lbs).

1.5.2 Stand-Lift Mechanism

The stand-lift mechanism weighs approximately 454 kg (1,000 lbs) without the helicopter mounted. Figure 1.5.2-1 presents diagrams of the two possible stand-lift configurations and Figure 1.5.2-2 presents various views of the trailer-mounted stand-lift mechanism.

1.5.3 Helicopter Targets

All dimensions and weights are provided for shipping purposes, without rotor blades. Tail rotors, when installed, add 38 cm (15 in) to the overall length and height at the tail end.

1.5.3.1 Mi-8 Hip

Length: 3.7 m (12 ft 2 in)
Width: 1.3 m (4 ft 3 in)
Height: 1.2 m (3 ft 11 in)
Weight: 18.2 kg (40 lbs)
Main Rotor: 3.7 m (12 ft 2 in) SAIC # C120
Tail Rotor: 3 blade

1.5.3.2 Mi-24 Hind-D

Length: 3.4 m (11 ft 1 in)
Width: 1.4 m (4 ft 8 in)
Height: 66 cm (2 ft 2 in)
Weight: 13.6 kg (30 lbs)
Main Rotor: 2.7 m (9 ft) SAIC # C119
Tail Rotor: 3 blade

1.5.3.3 Mi-28 Havoc

Length: 3.4 m (11 ft 2 in)
Width: 1.3 m (4 ft 3 in)
Height: 79 cm (2 ft 7 in)
Weight: 18.2 kg (40 lbs)
Main Rotor: 2.7 m (9 ft) SAIC #C122
Tail Rotor: 3 blade

CAUTION: This is the only 2.7 m (9 ft) rotor blade with a long shaft. Part number C119 is a 2.7 m (9 ft) blade with a short shaft and will not work on the Havoc.

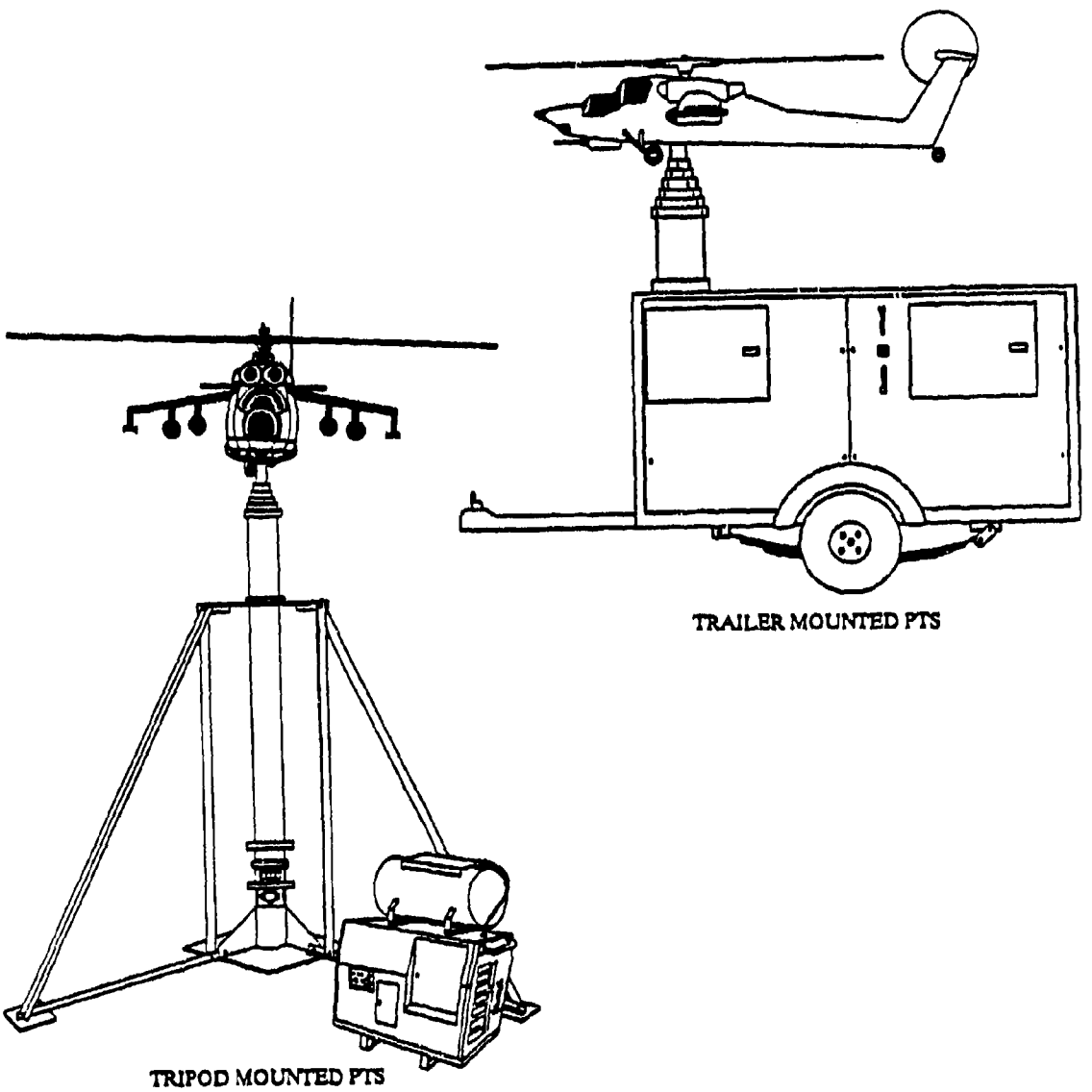


Figure 1.5.2-1. Pop-up target system

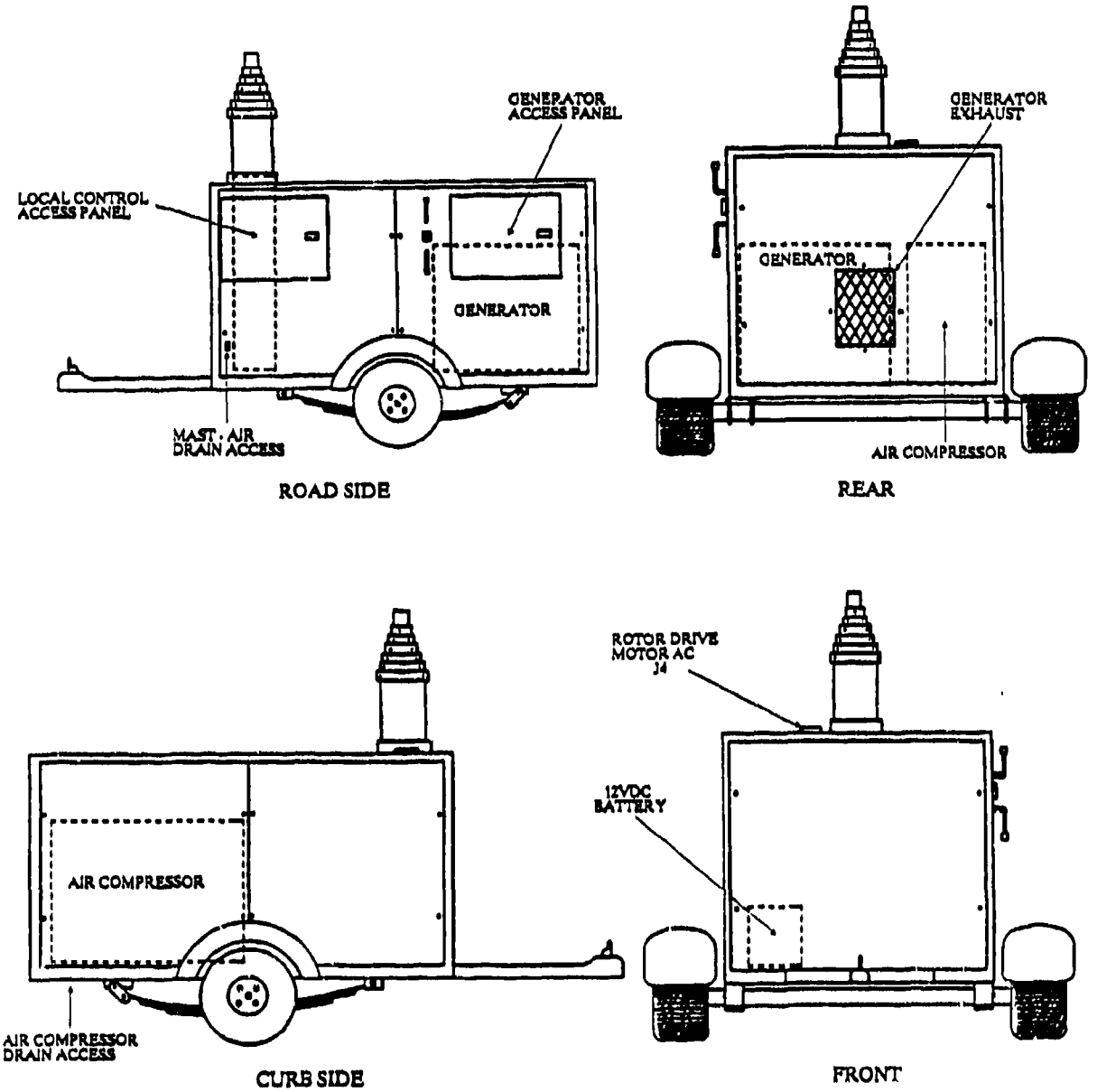


Figure 1.5.2-2. PTS trailer

1.5.3.4 Ka-?? Hokum
Length: 3 m (9 ft 9 in)
Width: 14 m (4 ft 7 in)
Height: 61 cm (2 ft)
Weight: 11.4 kg (25 lbs)
Main Rotor: 2.7 m (9 ft) SAIC #C119
Tail Rotor: none

1.5.3.5 AH-1S Cobra
Length: 2.8 m (9 ft 2 in)
Width: 74 cm (2 ft 5 in)
Height: 71 cm (2 ft 4 in)
Weight: 12.7 kg (28 lbs)
Main Rotor: 2.7 m (9 ft) SAIC #C119
Tail Rotor: 2 blade

1.5.3.6 AH-64 Apache
Length: 3 m (9 ft 10 in)
Width: 1.2 m (3 ft 11 in)
Height: 79 cm (2 ft 7 in)
Weight: 18.6 kg (41 lbs)
Main Rotor: 2.7 m (9 ft) SAIC #C119
Tail Rotor: 2 blade (2 each)

1.5.3.7 CH-3 Jolly Green Giant
Length: 3.6 m (11 ft 11 in)
Width: 1.3 m (4 ft 3 in)
Height: 81 cm (2 ft 8 in)
Weight: 15.9 kg (35 lbs)
Main Rotor: 3.6 m (11 ft 11 in) SAIC #C120
Tail Rotor: 5 blade

1.5.3.8 UH-1 Iroquois
Length: 2.6 m (8 ft 8 in)
Width: 48 cm (1 ft 7 in)
Height: 58 cm (1 ft 11 in)
Weight: 13.6 kg (30 lbs)
Main Rotor: 2.7 m (9 ft) SAIC #C119
Tail Rotor: 2 blade

1.5.3.9 UH-60A Blackhawk
Length: 3.1 m (10 ft 2 in)
Width: 89 cm (2 ft 11 in)
Height: 66 cm (2 ft 2 in)
Weight: 12.7 kg (28 lbs)
Main Rotor: 2.7 m (9 ft) SAIC #C119
Tail Rotor: 2 blade (2 each)

CAUTION: Secure the tail rotor on the CH-3 so it will not spin, to prevent it from being struck by the main rotor blade.

1.6 Power Requirements

1.6.1 RCS

The RCS requires 110-120V, 60 Hertz, single phase power at a single, three prong (grounded) outlet. This AC voltage is used by the equipment blower and the Universal Power Supply (UPS).

1.6.2 Stand-Lift Mechanism

The components of the stand-lift mechanism require 110-120V, 60 Hertz, single phase power or 12V DC. These requirements are met through the 3 kilowatt (kw) generator and 12V battery on each stand-lift mechanism. No external power is required.

1.7 Environmental Requirements

1.7.1 RCS

The RCS is designed to operate in a field environment; however, since digital equipment is being utilized, appropriate care must be exercised. Do not operate the RCS digital equipment where it is directly exposed to moisture or severe dust. To prevent "wash-out" of the screen it is recommended that it be operated away from direct sunlight. The RCS is designed to operate in temperatures ranging from -18° C (0° F) through 52° C (126° F).

1.7.2 Stand-Lift Mechanism and Target

The stand-lift mechanism with target mounted is designed to operate in temperatures ranging from -18° C (0° F) through 52° C (126° F), and in winds up to 40 km per hour (25 mph; 22 knots).

WARNING: The stand-lift mechanism must operate in an area free from all obstructions for a height of 12 meters (39 ft) and within a radius of 4 meters (13 ft) of the telescopic mast.

1.8 Items Furnished

1.8.1 RCS

The primary items comprising the RCS are contained in the white shipping and operating container. Refer to the RTS Operations Manual.

- Computer
- UPS
- Voice radio communications
- RF modem

Other RCS items not contained in the shipping and operating container are as follows:

- RF antenna and tripod
- AC power cord

1.8.2 Stand-Lift Mechanism

The items mounted in the stand-lift trailer are as follows:

- 3 kw generator
- Fuel tank (5 gallon)
- Air compressor
- Local control panel
  - RF modem
  - Stand-lift controller
  - Azimuth controller
  - Blower assembly
- 12V battery
- Telescopic mast assembly
- Main rotor drive assembly and helicopter mount
- 30 meter (100 ft) RF cable

Other items not contained in the stand-lift trailer are as follows:

- RF antenna and tripod

1.8.3 Helicopter Targets

The following items make up a helicopter target:

- Target body
- Main rotor blade
- Mount-to-mast adaptor
- Tail rotor

1.9 Items Required

1.9.1 RCS

The following must be provided for RCS operation:

- 120V 60 Hertz power at a single 3 prong outlet

1.9.2 Stand-Lift Mechanism

The following must be provided for operation of the stand-lift mechanism:

- Lubricant as required for the air system lubricator (Refer to the manufacturer's manual for proper lubricant.)
- Ground rod and strap (1 per stand-lift mechanism)
- Generator fuel

1.10 Tools and Test Equipment

1.10.1 Tools

Only common mechanic's tools are required for assembly and maintenance of the PTS. An exception is the extended key wrench, developed by SAIC, for securing the helicopter blades to the rotor drive motor. Due to differences among the US vendors who supply components to this system, both metric and inch-measure hardware will be encountered.

1.10.2 Test Equipment

A multimeter capable of measuring AC and DC potentials is the only test equipment required.

2.0 PREPARATION AND INSTALLATION INSTRUCTIONS

2.1 Unpacking and Assembly

Upon initial delivery of the PTS, all unpacking and assembly should be accomplished under the direction of SAIC personnel.

2.1.1 RCS

No assembly is required for the RCS.

2.1.2 Stand-Lift Mechanism

The telescopic mast must be installed as described in Section 5.2.2.3.

2.1.3 Helicopter Targets

All targets are shipped with their main rotor and tail rotor blades removed. Refer to Section 1.5.3 for determining the proper blades for each model of helicopter.

2.2 Emplacement

2.2.1 RCS

The RCS must be emplaced in an area which affords line-of-sight to the stand-lift mechanisms when the targets are raised. Refer to the RTS Operations Manual.

(1) Place the RCS cabinet in a dry, level location.

(2) Open the RCS cabinet and verify the following switch settings: Dataworld computer OFF; modem power OFF.

CAUTION: The RCS cabinet door must remain open during operation.

(3) Connect the AC input cable to the RCS generator.

(4) Install the RF antenna within 15 meters (50 ft) of the RCS cabinet. Verify that line-of-sight exists from the RCS antenna to all stand-lift mechanism antennas. Although greater distance may be achieved, the maximum range for reliable RF operation is considered to be 5 km (3 miles).

(5) Connect the RF cable from the antenna to the RCS RF modem.

CAUTION: Step 5 should not be performed until local checks have been completed at the PTS and all PTSs are fully energized.

(6) Prior to RF operations, verify the RF modem and RF amplifier are energized and ample voltage is supplied.

2.2.2 Stand-Lift Mechanism

The stand-lift mechanisms must be emplaced in locations which allow the personnel at the RCS to see the targets when they are raised.

To preclude early detection of targets by participating troops and to protect the stand-lift mechanisms during live fire operations, the stand-lift mechanisms should be protected by a berm of sufficient height so as to provide maximum cover, concealment, and protection to the PTS when the target is in its nested (down) position. Maximum height of a stand-lift mechanism, with target nested, is approximately 2.7 meters (9 ft).

(1) Place the stand-lift mechanism in a dry, level, protected location.

(2) Open the local control access and generator panels (see Figure 1.5.2-2) and verify the following switch settings:

SWITCH SETTINGS

Main power	OFF
Controller power	OFF
Modem power	OFF
Azimuth controller power	OFF

(3) Ground the generator.

(4) Install the RF antennas and tripods within 15 meters (50 ft) of each stand-lift mechanism. Verify that line-of-sight exists from each antenna to the RCS antenna. Install the antennas in locations which provide maximum protection during live fire operations.

(5) Connect the RF cable from the antenna to the RF amplifier on the stand-lift mechanism.

(6) Prior to RF operations, verify the RF modem and RF amplifier are energized and ample voltage is supplied.

2.2.3 Helicopter Targets

(1) Mount the proper tail rotor to the main body using the attached hardware (see Section 1.5.3).

NOTE: There are two types of main rotor drive assemblies and helicopter mounts, the mount with the large 10 amp drive motor is for use with Hokum only. There are three types of mount-to-mast adaptors, those constructed of plastic are not to be used with the Hokum 10 amp drive motor. Refer to Appendix A, Mast Assembly for more information.

(2) Place the proper main rotor drive assembly with drive motor mount in the mounting area on the helicopter body. Align the four mounting bolts with the helicopter body. Attach washers and nuts and tighten. Refer to Figure 2.2.3-1, and Appendix A, Mast Assembly.

WARNING: Drain all air from the air tank to prevent accidental raising of the telescopic mast assembly during the following procedures and disconnect J4, AC power to the drive motor.

(3) Lift the helicopter body over the mast and bolt it to the mounting bracket attached to the mast. Insert the rotor blade into the azimuth drive motor and tighten down rotor shaft using the chuck key. Refer to Figure 2.2.3-1; more detail on the assemblies can be found in Appendix A.

WARNING: Lift the helicopter body with a minimum of two persons (one front, one rear).

(4) Align the securing holes and insert the retaining pin.

(5) Attach the proper main rotor blade (Section 1.5.3) to the drive motor.

WARNING: Securely tighten the mounting chuck with the key wrench to prevent the rotor blades from coming off during rotation.

(6) Connect the AC power extension cord from the drive motor to J4 on the top of the stand-lift mechanism.

NOTE: To remove a helicopter target, reverse the above procedure.

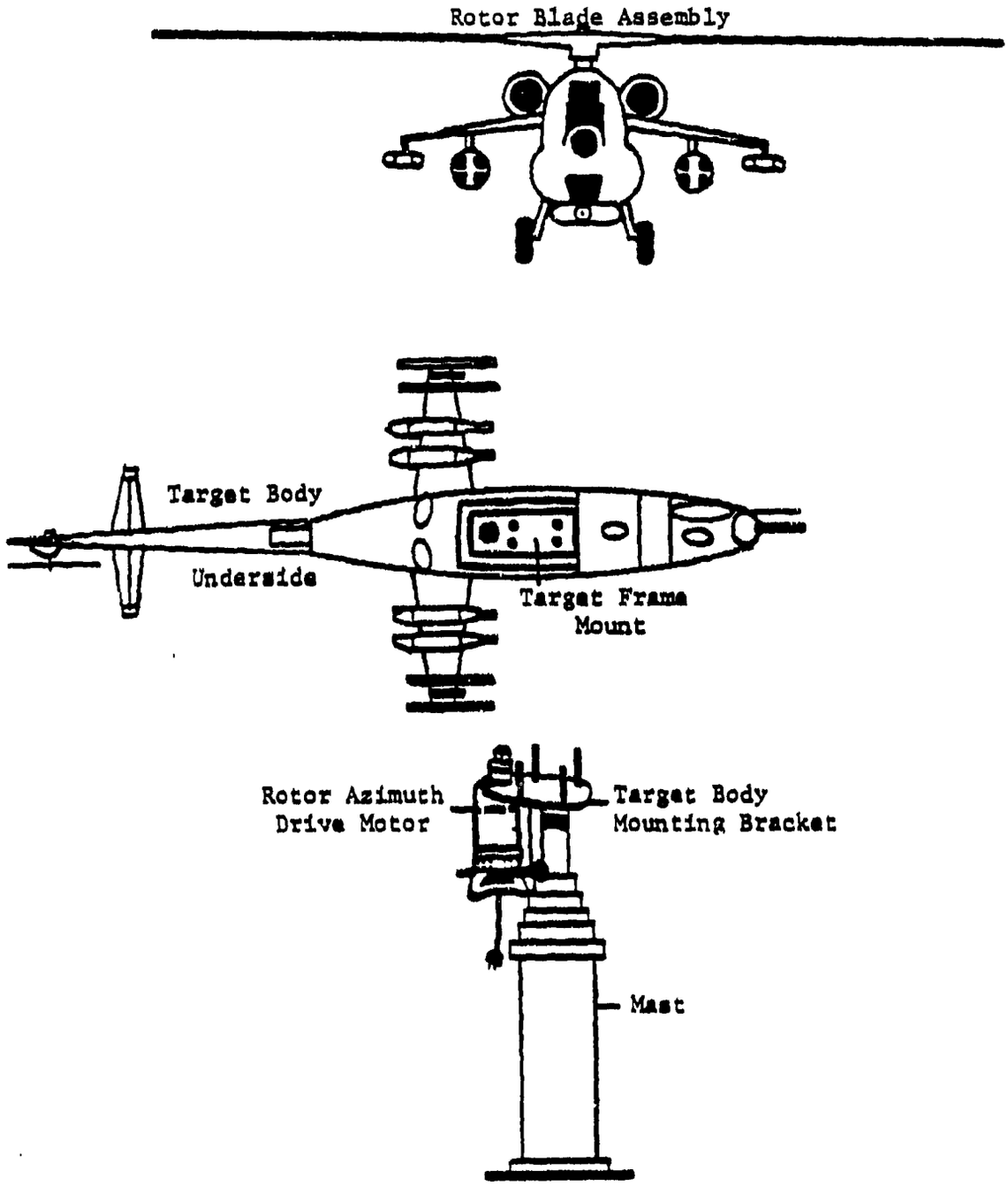


Figure 2.2.3-1. Helicopter mounting

3.0 GENERAL PRINCIPLES OF OPERATION

3.1 RCS

Remote control of the stand-lift mechanisms is from the computer at the RCS. A command sent from the computer, whether it results from an operator originated keystroke or from software execution of a scenario during Realtime operations, consists of an address message (stand #1, etc.) and a command message (UP, DOWN, etc.). Each of the stand-lift mechanisms is assigned a unique address and will only respond to RCS commands associated with that address.

3.2 Stand-Lift Mechanism

The stand-lift mechanism is a self-contained, portable platform enabling the raising, lowering, and rotation of the 1/5 scale helicopter targets. Control of these functions can be local at the PTS or remote from the RCS.

The stand-lift mechanism consists of four functional systems:

- AC power -- provides for the generation and distribution of all internal AC power
- DC power -- provides for the generation and distribution of all internal DC power
- Air -- provides compressed air to the telescopic mast assembly
- Control circuitry -- local and remote circuitry necessary to raise, lower, and rotate the helicopter target

3.2.1 AC Power Distribution

The 3 kw generator mounted on the stand-lift mechanism provides all 110-120V, 20 amp, single phase, 60 Hertz power, as well as 12V DC to maintain a charge on the 12V battery. It is gasoline powered, electric start, air cooled, and capable of sustained operations for 7 hours. It supplies power directly to the air compressor and through the ground fault circuit interrupter (GFCI) to the following:

- PTS controller
- Helicopter rotor drive motor
- 12V DC battery charger

AC distribution to the rotor drive motor is through an AC-DC relay. When an UP command is sent, air pressure to the mast closes the air switch, activates the drive motor, and raises the mast. When a DOWN command is sent, the air solenoid releases air pressure to the mast. The loss of pressure opens the air switch, stops the drive motor from rotating, and lowers the mast. The rotor test switch S5 on the local control panel allows for testing of rotor rotation without an UP command by bypassing the air switch. For safety reasons, S5 is a spring-loaded switch that is normally off.

3.2.2 DC Power Distribution

DC power necessary for the operation of the stand-lift mechanism comes from the on-board 12V battery. The battery is charged by a 12V DC battery charger which is powered by the 3 kw generator whenever it is running.

3.2.3 Air

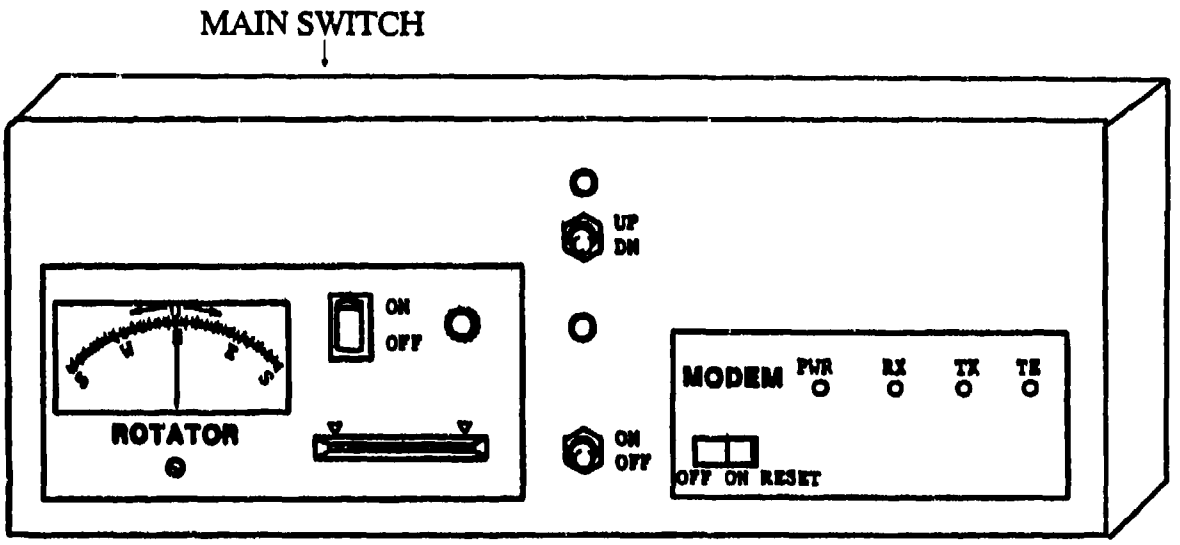
The air compressor is driven by a 3/4 horsepower, 115V, single phase drive motor turning at 1725 rpm. The pump is single stage, 2 cylinder feeding a 15 gallon storage tank. A safety valve is set for 150 psi. The air is regulated to provide the necessary pressure to raise the telescopic mast assembly on which the helicopter target is mounted. An air lubricator is also provided. This lubricator is necessary to prevent moisture from freezing in the air solenoid and mast during cold weather. Refer to the manufacturer's manual for proper lubrication and adjustment of the lubricator. The air compressor starts at approximately 80 psi and shuts off at approximately 100 psi. Air pressure is constantly applied to the air solenoid. When an UP command is sent, the air solenoid allows pressurized air to go into the telescopic mast assembly and to the air switch, closing it. A DOWN command results in air pressure in the mast being dumped through the air solenoid and the air switch opening.

3.2.4 Control Circuitry

Figure 3.2.4-1 depicts all control switches located with the PTS. The main power switch on the local control box activates the controller, cooling fan, power supply, RF modem, and Stack 65. The Stack 65, located inside the local control console box, contains output direct current (ODC) and output alternating current (OAC) modules. Grounds are applied to the inputs of the Stack 65 through the ODC-OAC to activate other control sources. An input to an ODC-OAC is indicated when the red lamp for that module is illuminated.

CAUTION: When a stand-lift mechanism is first energized, all the controller outputs are activated. This means that simultaneous UP, DOWN, RIGHT, and LEFT commands are present at the Stack 65 digital outputs of the controller. All these commands present at one time can cause damage to the azimuth controller and the air solenoid. To prevent this, ensure all switches are in the OFF position when the controller is activated. Upon activation, the grounds for UP, DOWN, RIGHT, and LEFT outputs to the Stack 65 are ready for operation.

NOTE: The output terminal grounds on the Stack 65 have internal jumpers.



Controller

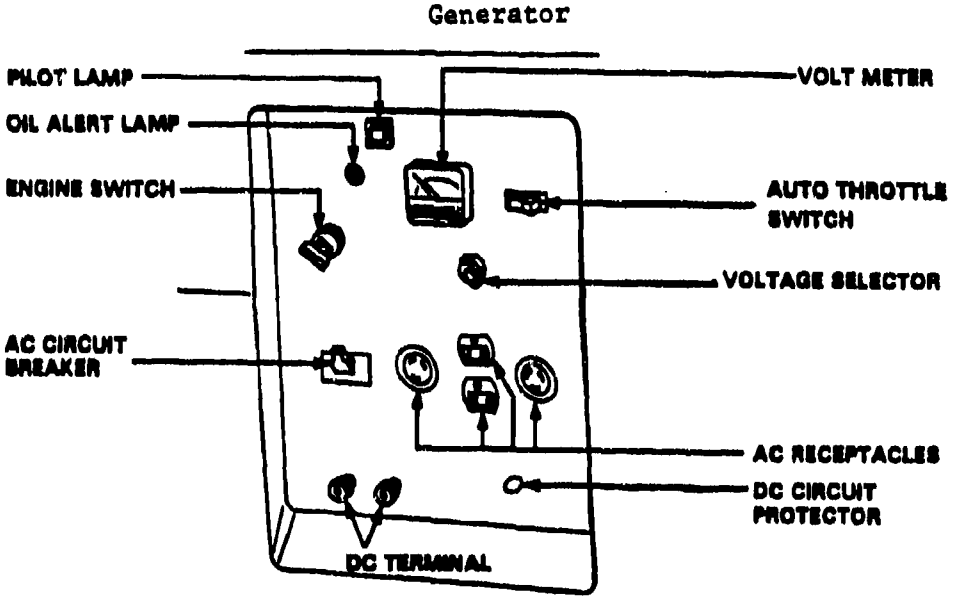


Figure 3.2.4-1. PTS controls

3.2.4.1 Local

The initial condition of a stand-lift mechanism (immediately after energizing) is with interrupt ON. This has no effect on local operation as the local test switch (S3) is between the controller outputs and the Stack 65. Placing S3 UP applies ground to the ODC of channel 6, energizing the UP portion of the air solenoid and raising the mast. Placing S3 DOWN applies the ground to the ODC of channel 7, energizing the DOWN portion of the air solenoid and lowering the mast. S3 is a three-position switch, normally left in the middle or OFF position. Once an UP command is stopped, the mast will stop raising and remain at its present position until a DOWN command is sent. S4 is a spring-loaded rotate switch; switching it LEFT or RIGHT applies grounds to the applicable OAC in the Stack 65 azimuth controller. This completes an AC circuit path for either a LEFT or RIGHT command. S4 is also normally OFF. Maximum rotation of the mast is approximately $\pm$ 178 degrees from the center position.

3.2.4.2 Remote

When in RF mode, commands reach the stand-lift mechanism through the antenna connected to and processed by the RF modem. In order to clear while in RF mode, a reset must first be sent from the computer to the modem or the modem itself must be reset. This also must be done whenever a PTS is shut down and then turned back on. The controller decodes commands from the RCS computer and sets the proper output at the RF modem from the signal it is receiving. All actions after that are the same as those previously discussed in Section 3.2.4.1, Local.

4.Ø SYSTEM START-UP, CHECK-OUT, AND SHUT-DOWN

4.1 System Start-Up

Prior to performing the start-up procedures in Table 4.1-1, verify that all components are properly assembled and emplaced as described in Section 2.Ø and in the RTS Operations Manual, and that adequate power is available to all components in accordance with Section 1.6. Verify that all generator fluid levels, grounding, and cabling are in accordance with the generator manufacturer's manual and the RTS Operations Manual.

4.2 Pre-Operation Checks

Pre-operation checks provided in Table 4.2-1 should be performed prior to integrated operations to verify that the individual components of the system are functioning properly. Perform initial checkout of all PTS stand-lift devices using the PTS control panel (Table 4.2-1). Proper operation indicates a "GO" (acceptable) condition. Any uncorrectable deviation results in a "NO-GO" (unacceptable) condition and should be reported to SAIC support personnel immediately.

WARNING: Rotor blades will begin to rotate upon receipt of an UP command and will continue to rotate for awhile after the target has been lowered. Maintain an area free of additional personnel and any obstructions for a radius of 4 meters (13 ft) from the telescopic mast assembly, and for a height of 12 meters (39 ft).

Verify PTS operations using the RCS computer as shown in Table 4.2-2. Refer to the RTS Operations Manual for more information. Prior to entering any commands to the RCS computer, verify that the CAPS LOCK key is locked down and the NUM key is not locked down.

CAUTION: Allow the target to reach fully extended height or send a STOP command prior to transmitting a DOWN command.

Table 4.1-1. Start-up Procedures

END ITEM	ACTION	RESULT
RCS	Connect AC power cord to AC source; connect RCS AC power cord from computer to UPS; connect RF modem AC adapter	Red lamp on modem illuminates
UPS	ON-OFF switch to ON	Green lamp illuminates
RF modem	ON-OFF switch to ON	All lamps flash; power lamp stays illuminated
Computer	ON-OFF switch to ON (adjust display for screen intensity and contrast)	Displayed is the main menu, a flashing cursor, and the prompt "INPUT NUMBER:?". (If display is different, press RESET).

Table 4.1-1 (Continued)

END ITEM	ACTION	RESULT
Stand-Lift Device		
Generator	Key to START-RUN	Generator runs. Green light on in approximately 15 seconds. Generator may run a bit rough until warm then smooth out when the auto-choke cuts in. Wait for this before proceeding.
	Voltage selector 120V 120/140 to 120V position.	
	Auto throttle to AUTO	Voltmeter reads 120V ± 20V
	Circuit breaker ON	Voltmeter reads 120V ± 20V. (Compressor starts if air pressure below 80 psi.)
Cooling fan	When main power is switched on, cooling fan automatically goes on.	Cooling fan starts to operate
Local control panel	Main power ON	Will hear cooling fan come on and yellow LED will illuminate
RF modem	ON/OFF switch to ON	Power lamp comes on; lamp stays illuminated
Azimuth controller	ON/OFF switch to ON	Indicator dial illuminates

WARNING: Prior to turning on the main circuit breaker, verify all switches on the local control panel are in the OFF position.

Table 4.2-1. Pre-operation Checks

END ITEM	ACTION	RESULT
RCS		
Computer	Energized	RTS main menu displayed
Stand-Lift Device		
Compressor	Open the air drain valve	Compressor starts at approximately 80 psi
	Close the air drain valve	Compressor stops at approximately 100 psi
Local control panel	UP	Mast extends to full height in 35 seconds, rotor blade rotates.
	Release UP command	
	LEFT (2-4 seconds)	Mast rotates LEFT
	RIGHT (2-4 seconds)	Mast rotates RIGHT
	DOWN	Mast begins to lower within 5 seconds and rotor blade rotation ceases.
	Release DOWN when the mast is fully nested.	

Table 4.2-2. PTS Test

PROMPT	ENTRY	RESULT
RCS		
Main menu appears	Select TEST and then select PTS	PTS and PLS Test options appear; upon selecting PTS the PTS stand numbers appear
1. TEST is displayed	Use arrow keys to select any option and press ENTER to select that option, regardless of the current menu level; press ESC to revert back to previous menu regardless of current menu level	TS and PLS displayed
2. PTS and PLS		Six PTS stand-lift devices to select from with first prompt. If any stand is selected, see next prompt.
3. Cursor on PTS #1 and PTS #1 chosen		PTS #1 (or whichever PTS was selected) displayed; cursor is on STOP
4. UP		PTS selected will raise until fully elevated
5. ROTATE CW		Target will rotate clock-wise on selected PTS
6. ROTATE CCW		Target will rotate counter-clockwise
7. DOWN		PTS selected will lower until fully nested
8. STOP		UP, DOWN, or ROTATE action ceases

4.3 Additional Operational Concerns

Prior to running any scenarios the following should be determined for each PTS: raise, hover, and lower times, and additional parameters. Calibrate each PTS as described in the RTS Operations Manual

NOTE: Maximum run time for a scenario is 999 seconds. After the scenario is over, for whatever the reason, any targets still up will have to be lowered by giving that target a DOWN command from the RCS computer.

NOTE: Upon initiation of Realtime, the scenario will begin to run. Executing an abort will immediately stop the scenario, lower all targets which may be raised, and return the RCS display to the main menu.

4.4 Shut-Down

Perform the procedures in Table 4.4-1 for system shut-down. Prior to performing the shut-down procedures, the telescopic mast assemblies on each PTS should be nested (i.e., fully lowered).

Table 4.4-1. Shut-down Procedures

END ITEM	ACTION	RESULT
RCS		
Computer	ON-OFF switch to OFF	Display screen goes blank
RF modem	ON-OFF switch to OFF	All lamps go off
UPS	ON-OFF switch to OFF	Green lamp goes off
Generator	Circuit breaker OFF; turn generator key to OFF position	AC is cut off; generator shuts off
Stand-Lift Device		
Azimuth controller	ON-OFF switch to OFF	Indicator dial lamp goes off
RF modem	ON-OFF switch to OFF	All lamps go off
Local control panel	Controller power to OFF	Controller lamp goes off
Main power	Switch to OFF	Blower goes off
Generator	Circuit breaker OFF; turn generator key to OFF position	AC is cut off; generator shuts off
Air compressor	Drain air tank	
Mast	Drain air line	

5.0 MAINTENANCE

Maintenance actions in this manual are authorized at the intermediate level. Additional maintenance actions not covered herein require SAIC or manufacturer (depot level) support and should not be attempted.

5.1 Preventive Maintenance

Most preventive maintenance is of a general housekeeping nature. For example, dusting and cleaning of peripheral items should be done periodically. Refer to manufacturer and vendor documentation on the RCS computer, mast assembly, generator, and air compressor for specific preventive maintenance actions and schedules.

5.2 Corrective Maintenance

5.2.1 RCS

5.2.1.1 Troubleshooting

Fault isolation of RCS malfunctions requires maintenance support (depot level). Before calling for maintenance, ensure that the entire system is properly emplaced, energized, and where applicable, that all RF modems have been initialized.

5.2.1.2 RF Modem Replacement

(1) Turn off the modem and then turn off the main power switch.

(2) Pull the controller out to its limits. Unscrew the power supply.

(3) Disconnect the power jack, RS232, and antenna.

(4) Place the new modem on the controller and secure the power supply with the screws.

(5) Connect the power jack, RS232 cable, and antenna.

(6) Use the LINK Program on the RCS computer to set the address of the RF modem (see Section 5.2.1.3).

5.2.1.3 RF Modem Set-up

The new modem should be connected to the RCS ribbon cable (#2). From the RCS computer operating system prompt, type: "TERM /2" and press <ENTER>. Press <RESET> on the modem. Verify 'signed-on' screen. Perform the functions below by typing the command, pressing <ENTER>, and entering the data. Press <F10> to quit.

COMMAND	PARAM	DESCRIPTION
FA		Factory defaults
RETRY	1	1 retry
XS	ON	Software handshaking ON
XH	OFF	Hardware handshaking OFF
PREFIX	Ø	No prefix character
GLOBAL	ON	Enable global receive
SET CON	99	Auto connect address is 99 (unused)
ADDR	No.	Address number
MESSFORM	ON	Format messages
ECHO	OFF	Don't echo inputs
PROMPT	OFF	No prompts
AUTOLF	OFF	Auto line feed OFF
SA		Save settings

Use these address codes to define the RF Modem type.

STATION TYPE	MODEM ADDRESS
PHTS	Stand number
DAS	100 + DAS number
PLS	200 + PLS number
RCS	254

5.2.1.4 Initialize the Stack 65

(1) Connect the null modem or connect the smart cable to the Stack 65 (the open RS232 port) and to the Tandy RS232 serial port. If using smart cable, set bits as follows: S-1 = A; S-2 = B; S-3 = C; S-4 = bits 1-6 OFF; bit 7 ON

(2) Energize the Tandy computer and type "TELCOM".

(3) Type "STAT 58N1E" and press <ENTER>. Next type "TERM" and press <ENTER>, or press <F4>.

(4) Hold the <C> key down and reset the Stack 65 (can power Stack down and then up to reset it).

(5) Verify that the Tandy computer displays: BTL BASIC CCCCC.

(6) Press <ESC> and then <U> (unprotect).

(7) Type "NEW". If error occurs go back to Step 6.

(8) Type "LIST". If a list appears go back to Step 7.

(9) Press <F3>.

(10) Type "PTS" to initialize a target system, or "WS" to initialize a weapon interface and press <ENTER>.

(11) Enter width of "100".

(12) After program is loaded, press <ESC>, then <P> (protect).

(13) Reset Stack 65.

5.2.2 Stand-Lift Mechanism

Refer to Appendix A for diagrams and parts locations during the replacement or adjustment of equipment.

5.2.2.1 Troubleshooting

Ensure that the entire system is properly emplaced, energized, and where applicable, that all RF modems are operating before calling for maintenance action. Symptoms typically occur in one stand only. For example, given the symptom of "No UP command received", it is assumed that other stands will go up. The following are the most common symptoms:

TROUBLE	PROBABLE CAUSE
No RF	Antenna, RF modem
No UP command No DOWN command	S3, controller, compressor, ODC, air solenoid
No LEFT command No RIGHT command	Azimuth controller or motor, controller, OAC
No rotor blade rotation	Air pressure, drive motor or cable, S3, AC-DC relay

5.2.2.2 Telescopic Mast Assembly

Corrective maintenance procedures are provided with the manufacturer documentation.

5.2.2.3 Mast Assembly Replacement

(1) Remove the helicopter target and rotor motor drive assembly.

(2) Drain air from the compressor air tank.

(3) Remove front panel from trailer.

(4) Drain air from base of the mast.

(5) Disconnect air line from base of mast.

(6) Remove the air drain cockpit assembly from base of mast.

(7) Remove the four 9/16" bolts holding the adapter plate to the azimuth drive motor.

(8) While two persons lift the mast, remove the four flat head screws securing the adapter plate to the mast.

(9) Lift the mast assembly straight up out the top of the trailer.

(10) To install a new mast, reverse the above procedure.

5.2.2.4 Azimuth Drive Motor Replacement

NOTE: Stand-lift mechanism must be removed from the 1/4 ton trailer to afford access to the motor's bottom mounting bolts.

(1) Disconnect the azimuth controller's AC power from the GFCI.

(2) Remove the helicopter target and rotor motor drive assembly.

(3) Remove front panel from trailer and drain air from the mast.

(4) Remove the four 9/16" bolts holding the adapter plate to the azimuth drive motor.

(5) From beneath the trailer, remove the four 9/16" bolts and lock washers securing the azimuth drive motor to the trailer floor.

(6) While two persons lift the mast, carefully remove the azimuth drive motor.

(7) Gently set the mast assembly on the trailer floor.

(8) Remove the cable leads from the azimuth drive motor.

Pin 1 White
Pin 2 Orange
Pin 3 Green
Pin 4 Blue
Pin 5 Yellow or Black
Pin 6 Red

(9) To replace the azimuth drive motor, reverse the above procedure and perform Azimuth Drive Alignment, Section 5.2.2.6.

CAUTION: Install new motor with terminals down.

5.2.2.5 Azimuth Controller Replacement

(1) Turn off the azimuth controller and disconnect the AC power cord from the GFCI.

(2) On the back of the azimuth controller, disconnect the following wires:

Pin 1 White
Pin 2 Orange
Pin 3 Green
Pin 4 Blue
Pin 5 Yellow or Black
Pin 6 Red

(3) Remove the azimuth controller

(4) To replace the azimuth controller, reverse the above procedure and perform Azimuth Drive Alignment, Section 5.2.2.6.

5.2.2.6 Azimuth Drive Alignment

This procedure must be performed whenever the azimuth drive motor or azimuth controller are replaced.

(1) Turn on the azimuth controller

(2) Press the LEFT control bar on the azimuth controller. Hold down until mast rotation ceases.

(3) Using a small screwdriver at the hole below the azimuth indicator, adjust the azimuth controller until the AZIMUTH INDICATOR reads 180° S at the left end of the meter scale.

(4) Press the RIGHT control bar on the azimuth controller. Hold down until mast rotation ceases.

(5) Adjust the azimuth controller until the AZIMUTH INDICATOR reads 180° S at the right end of the meter scale.

(6) Press and hold the LEFT control bar until the AZIMUTH INDICATOR reads 360° N.

5.2.2.7 Generator Replacement

(1) Remove the left-rear side panel and the rear panel from the PTS.

(2) Disconnect the fuel line to the fuel supply at the quick-disconnect.

(3) Disconnect the battery cables and remove any DC cable tie-downs connected to the generator frame.

(4) Disconnect any AC power-out cables at the generator control panel.

(5) Remove the four mounting bolts.

WARNING: The generator weighs 109 kg (240 lbs). After the mounting bolts are removed, care must be exercised to prevent injury to personnel when removing or replacing the generator.

(6) Slide the generator out the rear of the stand-lift mechanism.

(7) To install the new generator, reverse the above procedures.

5.2.2.8 Air Compressor Replacement

WARNING: The stand-lift mechanism must be dismounted from the 1/4 ton trailer and placed on a flat surface to prevent movement during the following procedure.

(1) Remove the two right-side panels and the rear panel from the PTS.

WARNING: Air pressure in excess of 100 psi can be encountered. Drain the air tank before proceeding.

(2) Disconnect the compressor AC line from the generator control panel.

(3) Using a 9/16" wrench, remove the air line from the air control valve.

(4) Disconnect the three electrical connectors at the air control valve.

NOTE: Hook-up is as follows:

A-B: ORANGE and BROWN to RED
A: ORANGE to WHITE
B: BROWN to BLACK

(5) Remove the four mounting bolts.

WARNING: The air compressor weighs 27 kg (59 lbs). After the mounting bolts are removed, care must be exercised to prevent injury to personnel when removing or replacing the air compressor.

(6) Slide the air compressor out the rear of the stand-lift mechanism.

(7) Remove the air solenoid assembly from the air tank.

(8) To install the new air compressor, reverse the above procedures.

5.2.2.9 Controller Unit Replacement

(1) Verify all power switches are off on the controller unit.

(2) Disconnect the DB25 cable from the controller, the AC source, and the antenna connector.

(3) Pull the controller unit out to its limits.

(4) On the back of the controller, disconnect the DB25 connector.

(5) Replace the controller chassis in its mount. Connect the power cord, the RS232 connector, and the antenna.

(6) Place the new controller unit on the mounting slides and secure.

5.2.2.10 Air Solenoid Replacement

(1) If required, lower the mast assembly and shut off the generator.

(2) Remove the front panel from the PTS.

WARNING: Air pressure in excess of 100 psi can be encountered. Drain the air from the tank and mast before proceeding.

(3) Remove the three leads from the air solenoid.

NOTE: Hook-up is as follows:

A-B: ORANGE and BROWN to RED
A: ORANGE to WHITE
B: BROWN to BLACK

(4) Disconnect the air solenoid to mast air line at the air solenoid.

(5) Disconnect the RED and BLACK 12V leads from the air switch.

(6) Rotate the entire air solenoid-regulator-lubricator assembly counter-clockwise. This will remove the assembly from the air tank.

NOTE: It may be necessary also to remove the front right panel.

(7) Disconnect the air line T from the A port of the air solenoid.

(8) On the replacement solenoid, verify that ports EB and B are plugged and that ports P, EA, and A are open.

(9) To install the new solenoid, reverse the above procedure.

(10) Close the air drain valves and pressurize the system.

(11) Verify that the mast (with target) extends fully in 35 seconds and retracts fully in 35 seconds. If times are incorrect, proceed to step 12.

(12) On the air regulator, pull up on the yellow knob to unlock the nut.

(13) Adjust the regulator as follows: counter-clockwise to increase raise time and decrease lower time, clockwise to decrease raise time and increase lower time.

(14) After properly adjusting the regulator, push down the yellow knob to lock the nut.

5.2.2.11 Air Regulator-Lubricator Replacement

(1) If required, lower the mast assembly and shut off the generator.

(2) Remove the front panel from the PTS.

WARNING: Air pressure in excess of 100 psi can be encountered. Drain the air from the tank and mast before proceeding.

(3) Remove the three leads from the air solenoid.

NOTE: Hook-up is as follows:

A-B: ORANGE and BROWN to RED
A: ORANGE to WHITE
B: BROWN to BLACK

(4) Disconnect the air solenoid to mast air line at the air solenoid.

(5) Disconnect the RED and BLACK leads from the air switch.

(6) Rotate the entire air solenoid-regulator-lubricator assembly counter-clockwise. This will remove the assembly from the air tank.

NOTE: It may be necessary also to remove the front right panel.

(7) Disconnect the air solenoid from the air lubricator at port P of the air solenoid.

(8) To install the new air regulator-lubricator, reverse the above procedure. Refer to the manufacturer's manual for proper lubricant to be put in the lubricator.

(9) Close the air drain valves and pressurize the system.

(10) Verify that the mast (with target) fully extends in 35 seconds and fully retracts in 35 seconds. If times are incorrect, proceed to step 11.

(11) On the air regulator, pull up on the yellow knob to unlock the nut.

(12) Adjust the regulator yellow knob as follows: counter-clockwise to increase raise time and decrease lower time, clockwise to decrease raise time and increase lower time.

(13) After properly adjusting the regulator, push down the yellow knob to lock the nut.

APPENDIX A:

POP-UP TARGET SYSTEM (PTS)

REPAIR PARTS AND PARTS LISTS

1.0 REPAIR PARTS

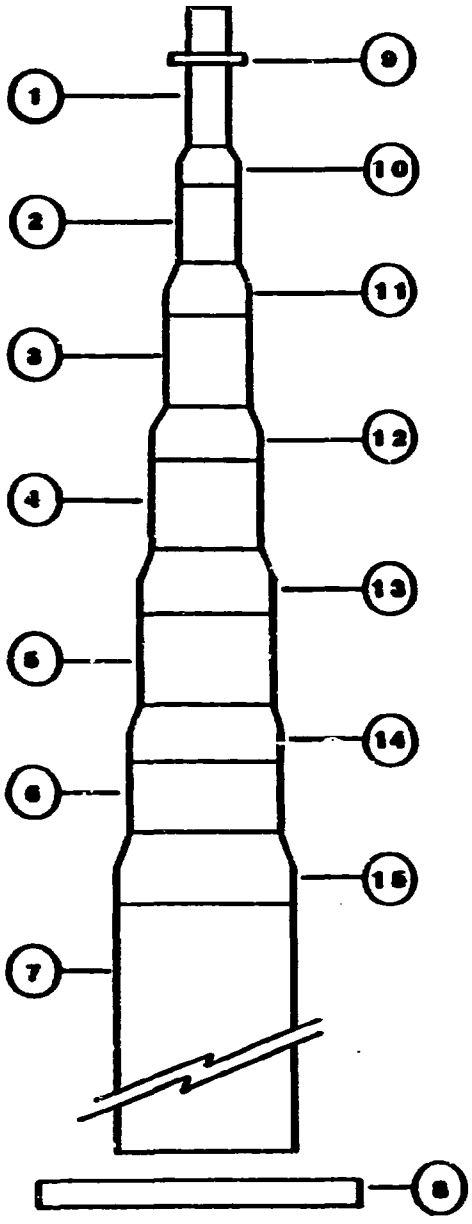
1.1 Introduction

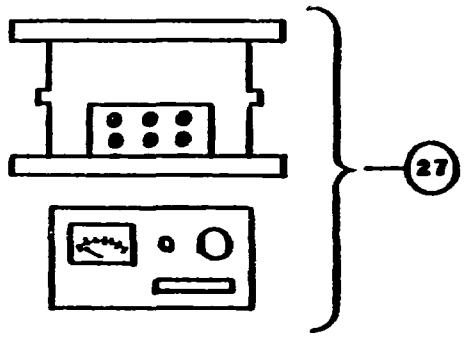
The items listed constitute repair parts used with the Pop-up Target System. Some apply only to the RF configuration and some apply only to the cable configuration. The RTS version is RF only. Replacement items may be ordered through SAIC or directly from the listed vendor, citing the vendor stock number. Items which are fabricated or assembled by SAIC are those which have SAIC listed as the vendor. Many of the principal items are depicted in Figure A-1, Repair Parts. For more detail on the Air System and Mast Assembly refer to Section 2.0 of this appendix.

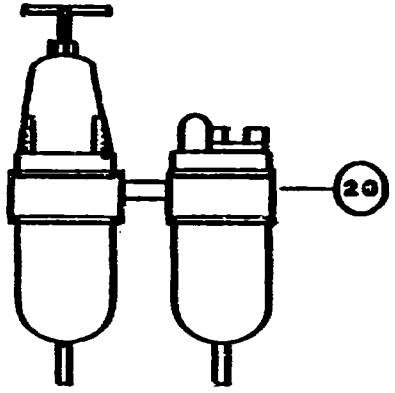
1.2 Repair Parts List

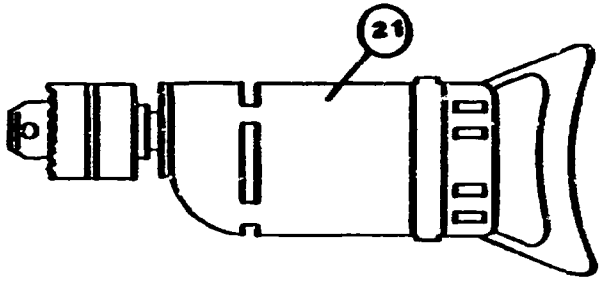
The following list of repair parts applies to all stand-lift mechanisms (RF and cable). This is followed by figures depicting the associated equipment. Some of the equipment items in the list do not apply to this manual, since this manual refers to the RF configuration and not the cable configuration.

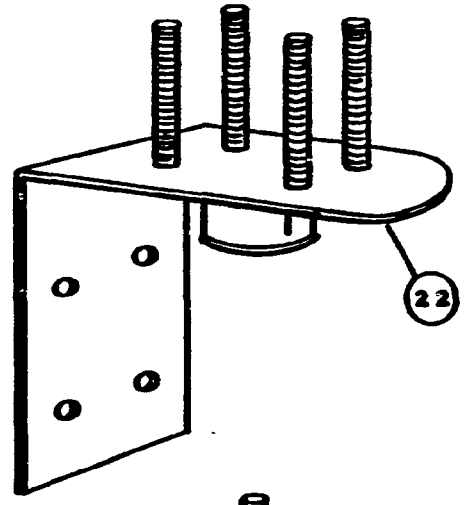
ITEM	VENDOR	STOCK NUMBER	MANUFACT	STOCK NUMBER	DESCRIPTION	QTY
01	Will-Burt	902571	Will-Burt	902571	Top mast section, 2"	6
02	Will-Burt	902572	Will-Burt	902572	Inter mast sec, 2.5"	5
03	Will-Burt	902573	Will-Burt	902573	Inter mast sec, 3"	4
04	Will-Burt	902574	Will-Burt	902574	Inter mast sec, 3.5"	2
05	Will-Burt	902575	Will-Burt	902575	Inter mast sec, 4"	1
06	Will-Burt	902576	Will-Burt	902576	Inter mast sec, 4.5"	1
07	Will-Burt	902577	Will-Burt	902577	Base mast section, 5"	1
08	Will-Burt	902600	Will-Burt	902600	Base plate and rotator	1
09	Will-Burt	902129	Will-Burt	902129	Top mast section stop	6
10	Will-Burt	902115	Will-Burt	902115	Collar, 2.5"	5
11	Will-Burt	902116	Will-Burt	902116	Collar, 3"	4
12	Will-Burt	902117	Will-Burt	902117	Collar, 3.5"	2
13	Will-Burt	902118	Will-Burt	902118	Collar, 4"	1
14	Will-Burt	902119	Will-Burt	902119	Collar, 4.5"	1
15	Will-Burt	902120	Will-Burt	902120	Collar, 5"	1
16	Will-Burt	902664	Will-Burt	902664	Neoprene seal set	5
17	Grainger	3Z852	Dayton		Air comp, 3/4hp,15gal	1
18	SAIC	C101			Hose assembly, 5',air	1
19	Will-Burt	900569	SMC Manu		NVSP43266151D Solenoid	1
20	Grainger	7Z556	Speedaire		Filter/reg/lub, 1/4"	1
21	Grainger	4Z591	B&Decker	1405	Drive motor, 10A,3/4"	1
22	SAIC	C102			Tgt mount assy, HOKUM	5
23	SAIC	C103			Target mount assembly	5
24	SAIC	C104			Mtr mount assy HOKUM	5
25	SAIC	C105			Mtr mount assy	5
26	SAIC	C106			Tgt mount assy (ext)	5
27	Will-Burt	HD73	Will-Burt	HD73	Rotator, az, electric	1
28	Grainger	1Z838	Speedaire		Regulator, fuel, 1/4"	2
29	SAIC	C107			Power cable assy, ret	5
30	M&M Honda	C108	Delco		Fuel pump, AC, 4 lb	2
31	M&M Honda	None	Honda	EX3300	Generator, AC, 110V	1
32	Newark	56F224	Magnecraft		W6140DSX1 Relay, K5	1
33	SAIC	C110			External fuel line	5
34	Ind Comm	BSA-150			Antenna, base station	2
35	SAIC	C111			Radio data link	1
36	Newark	47F1205	Magnecraft		W388CPX6 Relay, K1	1
37	SAIC	C112			RF coax cable 100'	2
38	SAIC	C113			Controller unit	1
39	SAIC	C114			Cable data link, intc	2
40	Radio Shk	270-1562			DC regulator, 6/9 v	1
41	Radio Shk	15-842			Mast, antenna, 3/4"	5
42	Radio Shk	15-516A			Mount, ant tripod, 3'	1
43	Ind Comm	C115			DC power supply	1
44	Radio Shk	26-3860			Encoder, RS200	1
45	SAIC	C116			Cable data link, fem	1
46	SAIC	C117			Cable data link, male	1
47	SAIC	C118			Cable data link, ext	1
48	SAIC	C119			Rotor blade, 9' (SS)	12
49	SAIC	C120			Rotor blade, 12' (LS)	6
50	Tool World	RVR 550			Drive motor, 6 amp	5
51	SAIC	C122			Rotor blade, 9' (LS)	4

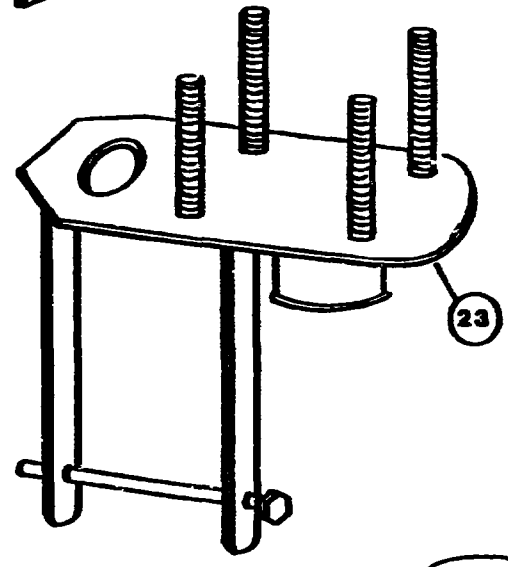


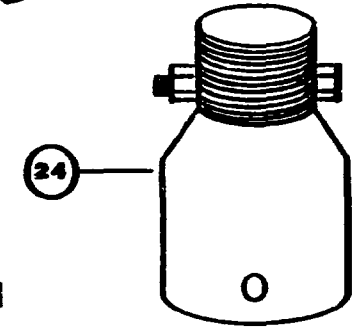






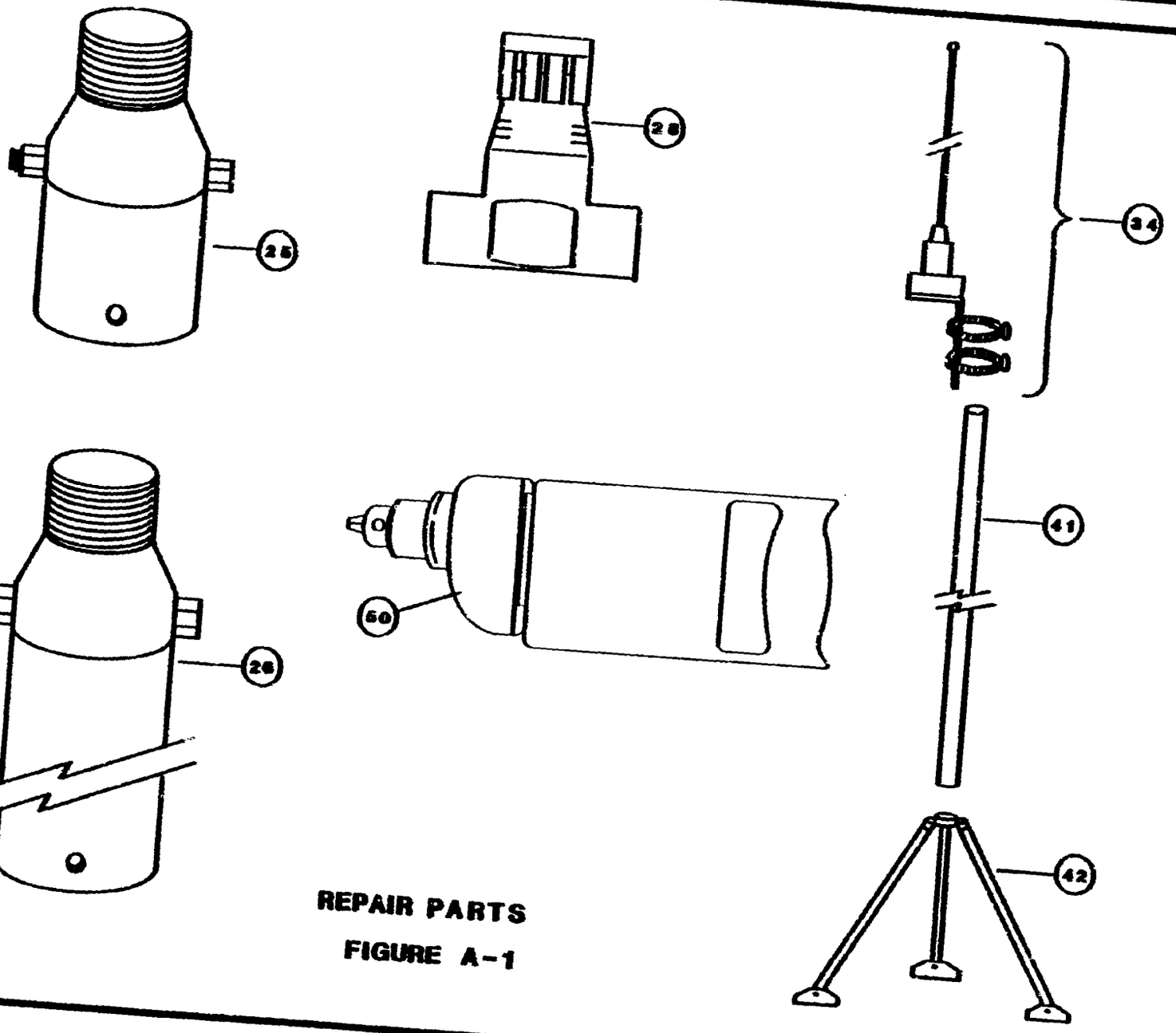






REPAIR PARTS

FIGURE A-1



REPAIR PARTS

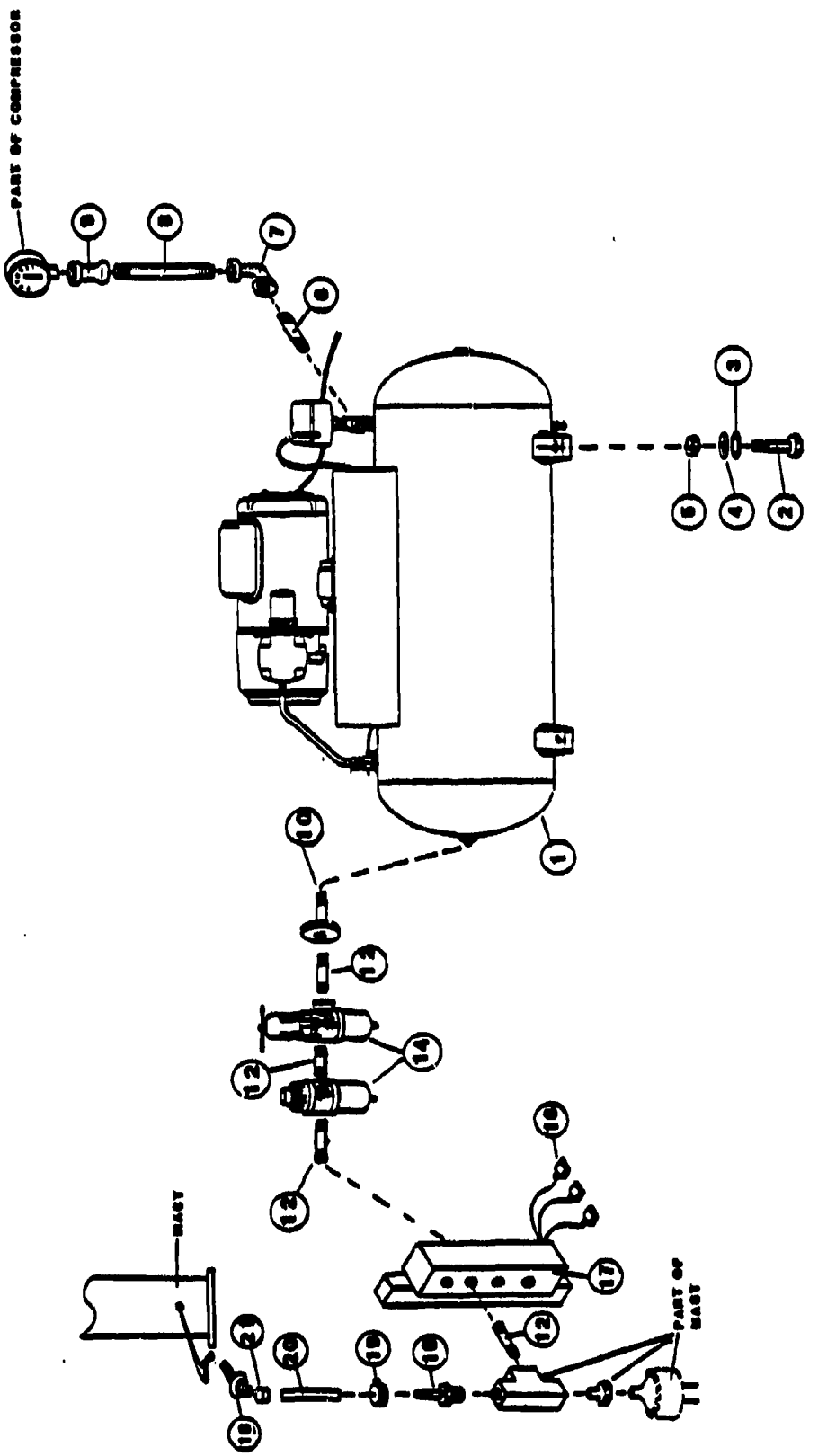
FIGURE A-1

2.0 AIR SYSTEM AND MAST ASSEMBLY BREAKDOWN

2.1 Air System

Refer to Figure A-2 for diagrams depicting major components of the air system.

ITEM	MATERIAL SOURCE	STOCK NUMBER	DESCRIPTION
1	Grainger	3Z852	Air comp, 3/4 hp, 15 gal
2	Cashway		Bolt, 3/8" x 2"
3	Cashway		Washer, lock, 3/8"
4	Cashway	674567	Washer, flat, 3/8"
5	Cashway	674427	Nut, 3/8"
6	EP Pipe		Nipple, galv, 1/4" x 2"
7	Cashway		Elbow, galv, 1/4", fem to fem
8	EP Pipe		Nipple, galv, 1/4" x 5"
9	EP Pipe		Coupler, 1/4" fem to fem
10	EP Pipe		Bushing, reducer, 3/4" x 1/4"
12	EP Pipe		Nipple, galv, 1/4" x 1"
14	Grainger	7Z556	Filter, regulator, lub, 1/4"
16	Grainger	5X424	Terminal, fem, Quick Slide
17	Will-Burt	900569	Solenoid, NVSP43266151D
18	Grainger	6X410	Hose barb, 3/8x3/8", MPT
19	Grainger	5X442	Clamp, 1/4 - 7/16", hose
20	Grainger	5W036	Hose, air, 3/8" ID, hvy dy
21	Grainger	2A734	Hose ferrule, 3/8" ID, brass



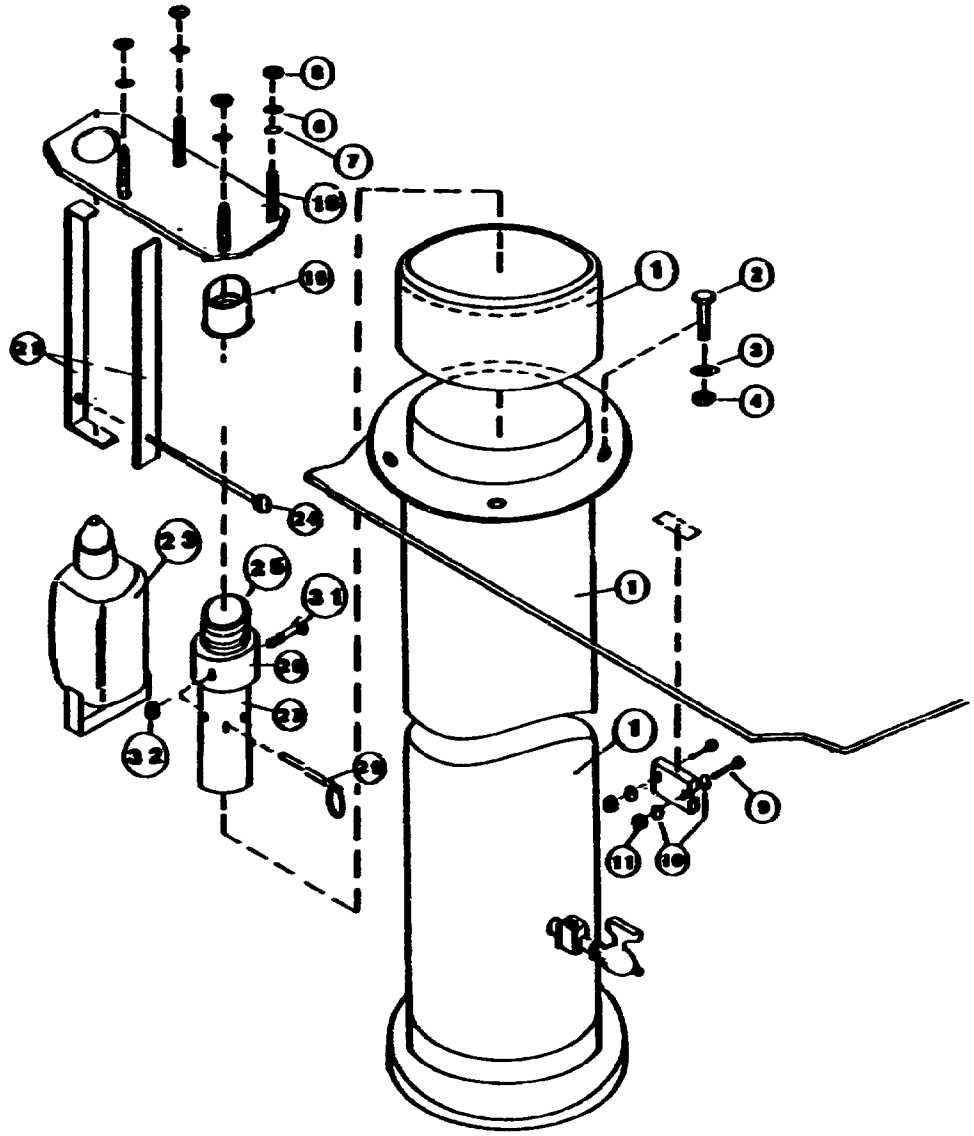
AIR SYSTEM

FIGURE A-2

2.2 Mast Assembly

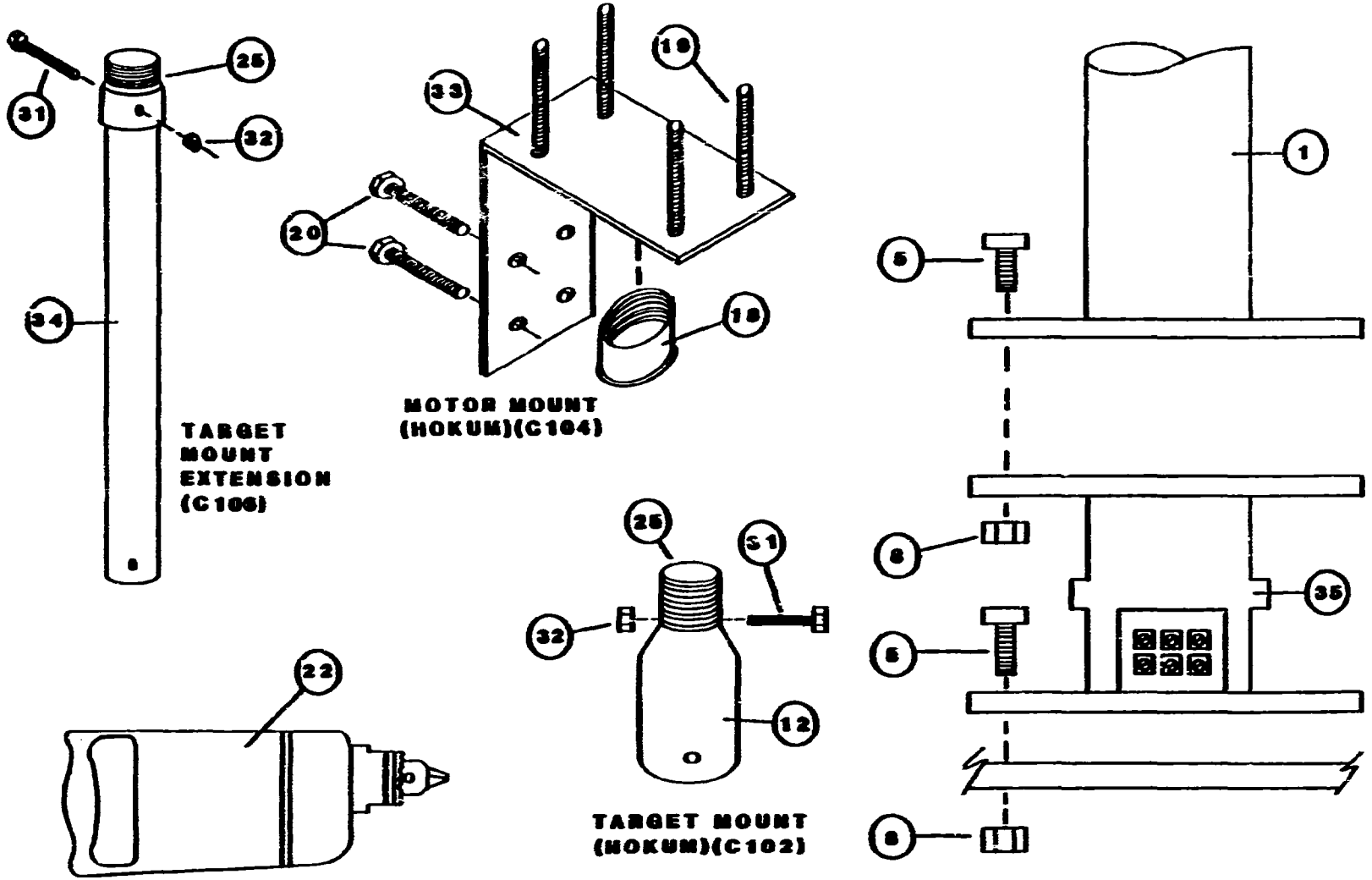
Refer to Figure A-3 for diagrams depicting major components of the mast assembly.

ITEM	MATERIAL SOURCE	STOCK NUMBER	DESCRIPTION
1	Will-Burt	7-34-167	Mast assy, 34', standard duty
2	Cashway		Bolt, 5/16 x 1 1/2"
3	Cashway	674559	Washer, flat, 5/16"
4	Cashway	653632	Nut, 5/16"
5	Cashway	638099	Bolt, 3/8" x 1 1/2"
6	Cashway		Washer, lock, 3/8"
7	Cashway	674567	Washer, flat, 3/8"
8	Cashway	674427	Nut, 3/8"
9	Newark	30F707	Screw, 8-32, machine, 3/4"
10	Newark	31F2140	Washer, #8, flat, 3/8"
11	Newark	31F2108	Nut, 8-32, 1/4", hex
12	SAIC		Extension tube
17	EP Pipe		Flat metal, 4 x 12 x 1/4"
18	Cashway		Coupler, galv, FPT, 2 3/8" OD
19	Cashway		Bolt, 3/8 x 3 1/2"
20			Bolt, part of Item 22
21	EP Pipe		Flat metal, 1 x 24 x 1/8"
22	Grainger	4Z591	Drill, 3/4", 10 amp, hvy dy
23	Tool Wld	RVR 550	Drive motor, 6 amp, 1/2"
24	Cashway	674125	Bolt, 5/16 x 5"
25	EP Alamo		Nipple, 3", metal
26	EP Alamo		PVC, 2 x 1 1/2" reducer
27	EP Alamo		PVC, 2" ID x 12"
29			Pin, quick release, part of Item 1
31	Cashway		Bolt, 1/4" x 3"
32	Cashway		Nut, 1/4"
33	EP Pipe		Flat metal, 4 x 12 x 1/4"
34	EP Alamo		PVC, 2" ID x 5'
35	Will-Burt	HD73	Rotator, azimuth, electric



MAST ASSEMBLY

FIGURE A-3



MAST ASSEMBLY

FIGURE A-3